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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 78.
L. O. HOWARD, Entomologist and Chief of Bureau

# ECONOMIC LOSS TO THE PEOPLE OF THE UNITED STATES THROUGH INSECTS THAT CARRY DISEASE.

BY

L. O. HOWARD, PH. D.
*Entomologist and Chief of Bureau.*

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# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
*Washington, D. C., January 15, 1909.*

Sir: I have the honor to recommend for publication as Bulletin 78 of this Bureau the accompanying manuscript entitled "Economic Loss to the People of the United States Through Insects that Carry Disease."

The United States is just awakening to a knowledge of the disastrous results following a lack of appreciation of the danger arising from the unchecked development of mosquitoes and the typhoid fly, and it is hoped that this bulletin will not only emphasize this danger, but will also lend support to movements, both local and widespread, toward the destruction (often so easy) of these carriers of disease.

Respectfully,

L. O. Howard,
*Entomologist and Chief of Bureau.*

Hon. James Wilson,
*Secretary of Agriculture.*

# CONTENTS.


| | Page. |
|---|---|
| Introduction | 7 |
| Mosquitoes | 8 |
| Malaria | 8 |
| Yellow fever | 17 |
| Work on the Isthmus of Panama | 21 |
| The typhoid fly, commonly known as the house fly | 23 |
| Endemic disease as affecting the progress of nations | 36 |
| Index | 39 |

# ECONOMIC LOSS TO THE PEOPLE OF THE UNITED STATES THROUGH INSECTS THAT CARRY DISEASE.

## INTRODUCTION.

It has been definitely proven and is now generally accepted that malaria in its different forms is disseminated among the individuals of the human species by the mosquitoes of the genus Anopheles, and that the malarial organism gains entrance to the human system, so far as known, only by the bite of mosquitoes of this genus. It has been proven with equal definiteness and has also become generally accepted that yellow fever is disseminated by the bite of a mosquito known as *Stegomyia calopus* (possibly by the bites of other mosquitoes of the same genus), and, so far as has been discovered, this disease is disseminated only in this way. Further, it has been scientifically demonstrated that the common house fly is an active agent in the dissemination of typhoid fever, Asiatic cholera, and other intestinal diseases by carrying the causative organisms of these diseases from the excreta of patients to the food supply of healthy individuals; and that certain species of fleas are the active agents in the conveyance of bubonic plague. Moreover, the tropical disease known as filariasis is transmitted by a species of mosquito. Furthermore, it is known that the so-called "spotted fever" of the northern Rocky Mountain region is carried by a species of tick; and it has been demonstrated that certain blood diseases may be carried by several species of biting insects. The purulent ophthalmia of the Nile basin is carried by the house fly. A similar disease on the Fiji Islands is conveyed by the same insect. Pink eye in the southern United States is carried by minute flies of the genus Hippelates. The house fly has been shown to be a minor factor in the spread of tuberculosis. The bedbug has been connected with the dissemination of several diseases. Certain biting flies carry the sleeping sickness in Africa. A number of dangerous diseases of domestic animals are conveyed by insects. The literature of the whole subject has grown enormously during the past few years, and the economic loss to the human species through these insects is tremendous. At the same time, this loss is entirely unnecessary; the diseases in question can be controlled, and the suppression of the conveying insects, so absolutely vital with certain of these diseases and so important in the others, can be brought about.

## MOSQUITOES.

Entirely aside from the loss occasioned by mosquitoes as carriers of specific diseases, their abundance brings about a great monetary loss in other ways.

Possibly the greatest of these losses is in the reduced value of real estate in mosquito-infested regions, since these insects render absolutely uninhabitable large areas of land available for suburban homes, for summer resorts, for manufacturing purposes, and for agricultural pursuits. The money loss becomes most apparent in the vicinity of large centers of population. The mosquito-breeding areas in the vicinity of New York City, for example, have prevented the growth of paying industries of various kinds and have hindered the proper development of large regions to an amount which it is difficult to estimate in dollars and cents and which is almost inconceivable. The same may be said for other large cities near the seacoast, and even of those inland in low-lying regions. The development of the whole State of New Jersey has been held back by the mosquito plague.

Agricultural regions have suffered from this cause. In portions of the Northwestern States it has been necessary to cover the work horses in the field with sheets during the day. In the Gulf region of Texas at times the market value of live stock is greatly reduced by the abundance of these insects. In portions of southern New Jersey there are lands eminently adapted to the dairying industry, and the markets of New York, Philadelphia, and the large New Jersey cities are at hand. In these localities herds of cattle have been repeatedly established, but the attacks by swarms of mosquitoes have reduced the yield of milk to such an extent as to make the animals unprofitable, and dairying has been abandoned for less remunerative occupations. The condition of the thoroughbred race horses at the great racing center, Sheepshead Bay, Long Island, was so impaired by the attacks of mosquitoes as to induce those interested to spend many thousands of dollars a few years ago in an effort to abate the pest.

All over the United States, for these insects, and for the house fly as well, it has become necessary at great expense to screen habitations. The cost of screening alone must surely exceed ten millions of dollars per annum.

## MALARIA.

The west coast of Africa, portions of India, and many other tropical regions have always, at least down to the present period, been practically uninhabitable by civilized man, owing to the presence of pernicious malaria. The industrial and agricultural development of Italy has been hindered to an incalculable degree by the prevalence of malaria in the southern half of the Italian peninsula, as well as in

the valley of the Po and elsewhere. The introduction and spread of malaria in Greece is stated by Ronald Ross, and with strong reasons, to have been largely responsible for the progressive physical degeneration of one of the strongest races of the earth.

In the United States, malaria, if not endemic, was early introduced. The probabilities are that it was endemic, and it is supposed that the cause of the failure of the early colonies in Virginia was due to this disease. It is certain that malaria retarded in a marked degree the advance of civilization over the North American Continent, and particularly was this the case in the march of the pioneers throughout the Middle West and throughout the Gulf States west to the Mississippi and beyond. In many large regions once malarious the disease has lessened greatly in frequency and virulence owing to the reclamation of swamp areas and the lessening of the number of the possible breeding places of the malarial mosquitoes, but the disease is still enormously prevalent, particularly so in the southern United States. There are many communities and many regions in the North where malaria is unknown, but in many of these localities and throughout many of these regions Anopheles mosquitoes breed, and the absence of malaria means simply that malarial patients have not entered these regions at the proper time of the year to produce a spread of the malady. It has happened again and again that in communities where malaria was previously unknown it has suddenly made its appearance and spread in a startling manner. These cases are to be explained, as happened in Brookline, Mass., by the introduction of Italian laborers, some of whom were malarious, to work upon the reservoir; or, as happened at a fashionable summer resort near New York City, by the appearance of a coachman who had had malaria elsewhere and had relapsed at this place. In such ways, with a rapidly increasing population, malaria is still spreading in this country.

To attempt an estimate of the economic loss from the prevalence of malaria in the United States is to attempt a most difficult task. Prof. Irving Fisher, in one of his papers before the recent International Tuberculosis Congress, declared that tuberculosis costs the people of the United States more than a billion dollars each year. In this estimate Professor Fisher considered the death rate for consumption, the loss of the earning capacity of the patients, the period of invalidism, and the amount of money expended in the care of the sick, together with other factors. In making these estimates he had a much more definite basis than can be gained for malaria. The death rate from malaria (as malaria) is comparatively small and is apparently decreasing. Exact figures for the whole country are not available. From a table comprising 22 cities it appears that two-thirds of the deaths from malaria in the United States occur in the South—one-third only in the North. The death rate from malaria

by States is available only for the following registration States: California, Colorado, Connecticut, District of Columbia, Indiana, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, South Dakota, and Vermont, all of which are Northern States. For these States the census reports from 1900 to 1907, inclusive, give the following death rates:

TABLE I.—*Deaths due to malaria in the registration States, 1900–1907.*

| Year. | Number of deaths from malaria per 100,000 population. | Total deaths from malaria. | Year. | Number of deaths from malaria per 100,000 population. | Total deaths from malaria. |
|---|---|---|---|---|---|
| 1900 | 7.9 | 2,434 | 1905 | 3.9 | 1,321 |
| 1901 | 6.3 | 1,791 | 1906 | 3.5 | 1,415 |
| 1902 | 5.4 | 1,738 | 1907 | 2.8 | 1,166 |
| 1903 | 4.3 | 1,410 | | | |
| 1904 | 4.2 | 1,391 | | | 12,666 |

Estimating, from the preceding table, the average annual death rate due to malaria at 4.8 per 100,000 population, and considering that the registration area includes only 16 of the Northern States (assuming fairly, however, that the death rate in the other Northern States is the same), it seems reasonably safe to conclude that the death rate from malaria for the whole United States must surely amount to 15 per 100,000. It is probably greater than this, since the statistics from the South are city statistics, and malaria is really a country disease. Thus it is undoubtedly safe to assume that the death rate for the whole population of the United States is in the neighborhood of 15 per 100,000. This would give an annual death rate from malaria of nearly 12,000 and a total number of deaths for the 8-year period 1900–1907 of approximately 96,000.

But with malaria perhaps as with no other disease does the death rate fail to indicate the real loss from the economic point of view. A man may suffer from malaria throughout the greater part of his life, and his productive capacity may be reduced from 50 to 75 per cent, and yet ultimately he may die from some entirely different immediate cause. In fact, the predisposition to death from other causes brought about by malaria is so marked that if, in the collection of vital statistics, it were possible to ascribe the real influence upon mortality that malaria possesses, this disease would have a very high rank in mortality tables. Writing of tropical countries, Sir Patrick Manson declares that malaria causes more deaths, and more predisposition to death by inducing cachectic states predisposing to other affections, than all the other parasites affecting mankind together. Moreover, it has been shown that the average life of the worker in malarious

places is shorter and the infant mortality higher than in healthy places.

But, aside from this vitally important aspect of the subject, the effect of malaria in lessening or destroying the productive capacity of the individual is obviously of the utmost importance, and upon the population of a malarious region is enormous, even under modern conditions and in the United States. It has been suggested that the depopulation of the once thickly settled Roman Campagna was due to the sudden introduction of malaria by the mercenaries of Scylla and Marius. Celli, in 1900, states that owing to malaria about 5,000,000 acres of land in Italy remain—not uncultivated, but certainly very imperfectly cultivated. Then also, in further example, in quite recent years malaria entered and devastated the islands of Mauritius and Réunion, practically destroying for a time the productiveness of these rich colonies of Great Britain and France.

Creighton, in his article on malaria in the Encyclopædia Britannica, states that this disease "has been estimated to produce one-half of the entire mortality of the human race; and inasmuch as it is the most frequent cause of sickness and death in those parts of the globe that are most densely populated, the estimate may be taken as at least rhetorically correct."[a]

Is it possible to make any close estimate of the ratio between the number of deaths from malaria and the number of cases of the same malady? No perfectly sound basis for such an estimate is apparent. In the English translation of Celli's work on "Malaria According to the New Researches," published in London in 1900, it is stated that the mortality from malaria in Italy from 1887 to 1898 varied from 21,033 in the first-named year to 11,378 in the last-named year, and the mean mortality for the period is assumed to be about 15,000. In 1896 a count of the patients in the hospitals in Rome was made, and the mortality rate of 7.75 per thousand of the actual patients was established. Calculating then on this basis, and at this rate, the number of cases per year for Italy was placed at about 2,000,000. According to this estimate, and with the average mortality for the United States of 12,000 as above indicated, the approximate number of cases for the United States would be about 1,550,000. It seems obvious, however, that Celli, in using the basis of hospital patients only, must have underestimated the number of cases for the Kingdom, since of the people in the country suffering from malaria the proportion entering the hospital must be relatively small. Therefore the death rate from malaria of malarial patients in the hospital must be greater than the death rate from malaria of the people who suffer from this disease in the whole country. In fact, so great must this

[a] See "Darwinism and Malaria," by R. G. Eccles, M. D., Medical Record, New York, January 16, 1909, pp. 85–93.

discrepancy necessarily be that it would not seem at all unlikely to the writer if the number of persons suffering from malaria in Italy were in reality nearer 3,000,000 than 2,000,000.

The same argument will hold for the United States, and more especially so since as a rule malaria in this country is of a lighter type than in Italy; in fact an estimate of 3,000,000 cases of malaria in the United States annually is probably by no means too high. It will not be an exaggeration to estimate that one-fourth of the productive capacity of an individual suffering with an average case of malaria is lost. Accepting this as a basis, and including the loss through death, the cost of medicines, the losses to enterprises in malarious regions through the difficulty of securing competent labor, and other factors, it is safe to place the annual loss to the United States from malarial disease under present conditions at not less than one hundred millions of dollars. Celli has shown that in Italy the great railway industries, for example, feel the effect of malaria greatly. According to accurate calculations one company alone, for 1,400 kilometers of railway and for 6,416 workmen in malarious zones, spends on account of malaria 1,050,000 francs a year. The same writer states that the army in Italy from 1877 to 1897 had more than 300,000 cases of malaria.

The loss to this country in the way of retardation of the development of certain regions, owing to the presence of malaria, is extremely great. Certain territory containing most fertile soil and capable of the highest agricultural productiveness is practically abandoned. With the introduction of proper drainage measures and antimosquito work of other character, millions of acres of untold capacity could be released from the scourge at a comparatively slight expenditure. These regions in the absence of malaria would have added millions upon millions to the wealth of the country. Drainage measures are now being initiated by the United States. Parties of engineers are being sent by the Government to make preliminary drainage surveys in the most prominent of these potentially productive regions. The following statement concerning the effect of malaria on the progress of this work has been made to the writer by Dr. George Otis Smith, director of the United States Geological Survey:

"In one of the Southern States 11 topographic parties have been at work during the past field season. The full quota for these parties would be 55 men, but I believe that something over 100 men have been employed at different times during the season. While I have not exact figures before me, I feel warranted in the statement that at least 95 per cent of these employees have been sick, for periods ranging from a few days up to two weeks, in the hospital. Many of them have been able later to return to work, but at least 30 per cent had to leave the field permanently. By reason of this sickness the effi-

ciency of the parties was reduced, at a very conservative estimate, by 25 per cent.

"In my recent visit in this field I found one man sick in each of the parties I saw and one man who had just returned from the hospital leaving the field for good. A similar state of things was reported from the other parties. I regard the sickness as practically all of a malarial nature, as extreme care was taken in all the camps to use nothing but boiled water except in a few instances where artesian water from great depths was available. In all the camps the tents have been screened, and in every case where the topographer has lived for any time 'on the country' there has been infection. As illustrating the value of the precautions generally taken by our camp parties, I might cite the fact that last year in West Virginia with 30 men living in camp, with typhoid fever prevalent in the neighborhood, no cases developed, while with 6 men living on the country where the same care could not be taken regarding the water supply, two cases of typhoid developed."

In estimating the weight of Doctor Smith's statement, it must be borne in mind that the men of his field parties are exceptionally intelligent and prepared to take all ordinary precautions.

Throughout the region in question malaria is practically universal. The railroads suffer, and at the stations throughout the territory it is practically impossible to keep operators steadily at work. This reduction in efficiency in the surveying parties and in the local railroad officials is moreover probably very considerably less than the reduction in the earning capacity of the entire population, which, however, is necessarily scanty.

In an excellent paper entitled "The relation of malaria to agricultural and other industries of the South," published in the Popular Science Monthly for April, 1903, Prof. Glenn W. Herrick, then of the College of Agriculture of Mississippi, after a consideration of the whole field, concludes that malaria is responsible for more sickness among the white population of the South than any disease to which it is now subject. The following forcible statement referring to the States of Louisiana, Mississippi, Alabama, Georgia, and South Carolina is in Professor Herrick's words:

"We must now consider briefly what 635,000 or a million cases of chills and fevers in one year mean. It is a self-evident truth that it means well for the physician. But for laboring men it means an immense loss of their time together with the doctors' fees in many instances. If members of their families other than themselves be affected, it may also mean a loss of time together with the doctors' fees. For the employer it means the loss of labor at a time perhaps when it would be of greatest value. If it does not mean the actual loss of labor to the employer it will mean a loss in the efficiency of

his labor. To the farmers it may mean the loss of their crops by want of cultivation. It will always mean the noncultivation or imperfect cultivation of thousands of acres of valuable land. It means a listless activity in the world's work that counts mightily against the wealth-producing power of the people. Finally it means from two to five million or more days of sickness with all its attendant distress, pain of body, and mental depression to some unfortunate individuals of those five States."

Referring to the Delta region in Mississippi, which lies along the Mississippi River in the western part of the State of Mississippi, extending from the mouth of the Yazoo River north nearly to the Tennessee line, Herrick says that it is the second best farming land in the world, having only one rival, and that is the valley of the Nile. "Still," says Herrick, "this land to-day, or at least much of it, can be bought at ten to twenty dollars an acre. Thousands of acres in this region are still covered with the primeval forest, and the bears and deer still roaming there offer splendid opportunities for the chase, as evidenced by the late visit of our Chief Executive to those regions for the purpose of hunting. Why is not this land thickly settled? And why is it not worth from two to five hundred dollars an acre? If it produces from one to two or more bales of cotton to an acre, and it does, it ought to be worth the above named figures. A bale of cotton to the acre can be produced for thirteen dollars, leaving a net profit of twenty to forty dollars for each bale, or forty to eighty or more dollars for each acre of land cultivated. Moreover, this land has been doing that for years, and will do it for years to come, without the addition of one dollar's worth of fertilizer. Land that will produce a net profit of forty to eighty dollars an acre is a splendid investment at one, two, or even three hundred dollars an acre. Yet this land does not sell in the market for anything like so much, because the demand is not sufficient, for white people positively object to living in the Delta on account of malarial chills and fevers. A man said to me not long ago that he would go to the Delta that day if he were sure that his own life or the lives of the members of his family would not be shortened thereby. There are thousands exactly like him, and the only reason that these thousands do not go there to buy lands and make homes is on account of chills and fevers. But there is a time coming, and that not far distant, when malaria in the Delta will not menace the would-be inhabitants. When that time comes it will be the richest and most populous region in the United States."

Malaria is a preventable disease. It is possible for the human species to live and to thrive and to produce in malarious regions, but at a very considerable inconvenience and expense. The Italian investigators, and especially Celli and his staff, have shown that by

screening the huts of the peasants on the Roman Campagna and by furnishing field laborers with veils and gloves when exposed to the night air, it is possible even in that famous hotbed of malaria to conduct farming operations with a minimum of trouble from the disease. Moreover, Koch and his assistants in German East Africa have shown that it is possible, by stamping out the disease among human beings by the free use of medicine, that a point can be gained where there is small opportunity for the malarial mosquitoes to become infected. Moreover, the work of the parties sent out by the Liverpool School of Tropical Medicine and other English organizations to the west coast of Africa has shown that by the treatment of malarial-mosquito breeding pools the pernicious coast fever may be greatly reduced. Again, the work of Englishmen in the Federated Malay States has shown that large areas may be practically freed from malaria. The most thorough and the most satisfactory of all measures consists in abolishing the breeding places of the malarial mosquitoes. In regions like the Delta of the Mississippi this involves extensive and systematic drainage, but in very many localities where the breeding places of the Anopheles mosquitoes can be easily eradicated, where they are readily located and are so circumscribed as to admit of easy treatment, it is possible to rid the section of malaria at a comparatively slight expense.

With a general popular appreciation of the industrial losses caused primarily by the malarial mosquito and secondarily by the forms which do not carry malaria, as indicated in the opening paragraphs, it is inconceivable that the comparatively inexpensive measures necessary should not be undertaken by the General Government, by the State governments, and by the boards of health of communities, just as it is inconceivable that the individual should suffer from malaria and from the attacks of other mosquitoes when he has individual preventives and remedies at hand. Large-scale drainage measures by the General Government involving large sections of valuable territory have been planned and are practically under way; certain States, notably New Jersey and New York, are beginning to work; communities all over the country through boards of health are also beginning to take notice, while popular education regarding the danger from mosquitoes and in regard to remedial measures is rapidly spreading. But all of this interest should be intensified, and the importance of the work should be displayed in the most emphatic manner, and relief from malaria and other mosquito conditions should be brought about as speedily as possible.

A few excellent examples of antimalarial work may be instanced.

The latest reports on the measures taken to abolish malaria from Klang and Port Swettenham in Selangor, Federated Malay States, indicate the most admirable results. These measures were under-

taken first in 1901 and 1902, and have been reported upon from time to time in the Journal of Tropical Medicine. The expenditure undertaken by the Government with a view to improving the health of the inhabitants of these towns has been fully justified by the results, which promise to be of permanent value. The total expenditure for the town of Klang down to the end of 1905 was £3,100 ($15,086), and the annual permanent expenditure is about £60 ($292) for clearing earth drains and £210 ($1,022) for town gardeners. For Port Swettenham the total expenditure to the end of 1905 was £7,000 ($34,065), and the annual cost of keeping up the drains, etc., is approximately £40 ($195) for clearing earth drains, and £100 ($487) for town gardeners.

The careful tabulation of cases and deaths and of the results of the examination of blood of children in especially drained areas indicates the following conclusions: (1) Measures taken systematically to destroy breeding places of mosquitoes in these towns, the inhabitants of which suffered terribly from malaria, were followed almost immediately by a general improvement in health and decrease in death rate. (2) That this was due directly to the work carried out and not to a general dying out of malaria in the district is clearly shown by figures pointing out that while malaria has practically ceased to exist in the areas treated it has actually increased to a considerable extent in other parts of the district where antimalarial measures have not been undertaken.

The statistics for 1905 are even more favorable than those for 1902, which gives a very strong evidence in favor of the permanent nature of the improvement carried out. In fact it seems as though malaria has been permanently stamped out at Klang and Port Swettenham by work undertaken in 1901, and this experience in the Malay States should be of value to those responsible for the health of communities similarly situated in many other parts of the world.

Another striking example of excellent work of this kind is found in the recently published report on the suppression of malaria in Ismailia, issued under the auspices of the Compagnie Universelle du Canal Maritime de Suez. Ismailia is now a town of 8,000 inhabitants. It was founded by De Lesseps in April, 1862, on the borders of Lake Timsah, which the Suez Canal crosses at mid-distance between the Red Sea and the Mediterranean. Malarial fever made its appearance in very severe form in September, 1877, although the city had up to that time been very healthy, and increased so that since 1886 almost all of the inhabitants have suffered from the fever. In 1901 an attempt to control the disease was made on the mosquito basis, and this attempt rapidly and completely succeeded, and after two years of work all traces of malaria disappeared from the city. The work was directed not only against Anopheles mosquitoes, but

against other culicids, and comprised the drainage of a large swamp and the other usual measures. The initial expense amounted to 50,000 francs ($9,650), and the annual expenses since have amounted to about 18,300 francs ($3,532).

The results may be summarized about as follows: Since the beginning of 1903 the ordinary mosquitoes have disappeared from Ismailia. Since the autumn of 1903 not a single larva of Anopheles has been found in the protected zone, which extends to the west for a distance of 1,000 meters from the first houses in the Arabian quarter and to the east for a distance of 1,800 meters from the first houses in the European quarter. After 1902 malarial fever obviously began to decrease, and since 1903 not a single new case of malaria has been found in Ismailia.

A very efficient piece of antimalarial work was accomplished in Havana during the American occupation of 1901 to 1902, incidental in a way to the work against yellow fever. An Anopheles brigade of workmen was organized under the sanitary officer, Doctor Gorgas, for work along the small streams, irrigated gardens, and similar places in the suburbs, and numbered from 50 to 300 men. No extensive drainage, such as would require engineering skill, was attempted, and the natural streams and gutters were simply cleared of obstructions and grass, while superficial ditches were made through the irrigated meadows. Among the suburban truck gardens Anopheles bred everywhere, in the little puddles of water, cow tracks, horse tracks, and similar depressions in grassy ground. Little or no oil was used by the Anopheles brigade, since it was found in practice a simple matter to drain these places. At the end of the year it was very difficult to find water containing mosquito larvæ anywhere in the suburbs, and the effect upon malarial statistics was striking. In 1900, the year before the beginning of the mosquito work, there were 325 deaths from malaria; in 1901, the first year of the mosquito work, 171 deaths; in 1902, the second year of mosquito work, 77 deaths. Since 1902 there has been a gradual though slower decrease, as follows: 1903, 51; 1904, 44; 1905, 32; 1906, 26; 1907, 23. These results, although less striking than those from Ismailia, involved a smaller expense in money and show surely an annual saving of 300 lives, and undoubtedly a corresponding decrease in the number of malarial cases, which may be estimated upon our earlier basis at something less than 40,000.

## YELLOW FEVER.

Yellow fever has prevailed endemically throughout the West Indies and in certain regions on the Spanish Main virtually since the discovery of America. Barbados, Jamaica, and Cuba suffered epidemics before the middle of the seventeenth century. There were

outbreaks in Philadelphia, Charleston, and Boston as early as 1692, and for a hundred years there were occasional outbreaks, culminating in the great Philadelphia epidemic of 1793. Northern cities were able, by rigid quarantine measures, to prevent great epidemics after the early part of the nineteenth century, but from the West Indies the disease was occasionally introduced and prevailed from time to time epidemically in the Southern States. In 1853 it raged throughout this region, New Orleans alone having a mortality of 8,000. The last widespread epidemic occurred in 1878, chiefly in Louisiana, Alabama, and Mississippi, but spreading up the Mississippi Valley as far as Cairo, Ill., and attacking with virulence the city of Memphis, Tenn. In this year there were 125,000 cases and 12,000 deaths. In 1882 there were 192 deaths at Pensacola; in 1887, 62 deaths in the Southern States; in 1893, 52 deaths; in 1897, 484; in 1898, 2,456 cases with 117 deaths; in 1903, 139 deaths were recorded, mostly at Laredo, Tex., and in 1905 there was a serious outbreak at New Orleans and in neighboring towns, including one locality in Mississippi, in which 911 deaths were recorded for the whole country.

The actual loss of life from yellow fever during all these years, when compared with the loss from other diseases, has been comparatively slight, but the death rate is perhaps the most insignificant feature of the devastation which yellow fever epidemics have produced, and the disease itself has been but a small part of the affliction which it has brought to the Southern States. The disease once discovered in epidemic form, the whole country has become alarmed; commerce in the affected region has come virtually to a standstill; cities have been practically deserted; people have died from exposure in camping out in the highlands; rigid quarantines have been established; innocent persons have been shot while trying to pass these quarantine lines; all industry for the time has ceased. The commerce of the South during the epidemic of 1878, for example, fell off 90 per cent, and the hardships of the population can not be estimated in monetary terms. With such industrial and commercial conditions existing from Texas to South Carolina, many industries at the North have suffered, and, in fact, the effect of a yellow fever summer in the South has been felt not only all over the United States, but in many other portions of the world.

All these conditions, as bad as they have been, do not sum up the total loss to the national prosperity during past years. Cities like Galveston, New Orleans, Mobile, Memphis, Jacksonville, and Charleston, subject to occasional epidemics, as they have been in the past, have not prospered as they should have done. Their progress has been greatly impeded by this one cause, and thus the industrial development of the entire South has been greatly retarded.

Physicians have been theorizing about the cause of yellow fever from the time when they began to treat it. It was thought by many that it was carried in the air; by others that it was conveyed by the clothing, bedding, or other articles which had come in contact with a yellow-fever patient. There were one or two early suggestions of the agency of mosquitoes, but practically no attention was paid to them, and they have been resurrected and considered significant only since the beginning of the present century. With the discovery of the agency of micro-organisms in the causation of disease, a search soon began for some causative germ. Many micro-organisms were found in the course of the autopsies, and many claims were put forth by investigators. All of these, however, were virtually set at rest by Sternberg in his "Report on the Etiology and Prevention of Yellow Fever," published in 1890, but a claim made by Sanarelli in June, 1897, for a bacillus which he called *Bacillus icteroides* received considerable credence, and in 1899 it was accepted in full by Wasden and Geddings, of the United States Marine-Hospital Service, who reported that they had found this bacillus in thirteen or fourteen cases of yellow fever in the city of Havana. There is no evidence, however, that this bacillus has anything to do with yellow fever. In 1881 Finlay, of Havana, proposed the theory that yellow fever, whatever its cause may be, is conveyed by means of *Culex* (now *Stegomyia*) *fasciatus* (now *calopus*). Subsequently he published several important papers, in which his views were modified from time to time, and in the course of which he mentioned experiments with 100 individuals, producing 3 cases of mild fever. None of the cases, however, was under his full control, and the possibility of other methods of contracting the disease was not excluded. Therefore, his theory, while it was received with interest, was not considered to be proved.

In 1890 came the beginning of the true demonstration. An army board was appointed by Surgeon-General Sternberg for the purpose of investigating the acute infectious diseases prevailing in the island of Cuba. The result achieved by this board, consisting of Reed, Carroll, Lazear, and Agramonte, was a demonstration that yellow fever is carried by *Stegomyia calopus*, and their ultimate demonstration was so perfect as to silence practically all expert opposition. The Third International Sanitary Convention of the American Republics unanimously accepted the conclusion that yellow fever is carried by this mosquito, and that the Stegomyia constitutes the only known means by which the disease is spread. To-day, after abundant additional demonstration, the original contention of Reed, Carroll, and Agramonte (Lazear having died in the course of the experiments) is a part of the accepted knowledge of the medical world. The importance of the discovery can not be overestimated, and its first demonstration was followed by antimosquito measures in the city

of Havana, undertaken under the direction of Gorgas, with startling results.

Yellow fever had been endemic in Havana for more than one hundred and fifty years, and Havana was the principal source of infection for the rest of Cuba. Other towns in Cuba could have rid themselves of the disease if they had not been constantly reinfected from Havana. By ordinary sanitary measures of cleanliness, improved drainage, and similar means the death rate of the city was reduced, from 1898 to 1900, from 100 per thousand to 22 per thousand; but these measures had no effect upon yellow fever, this disease increasing as the nonimmune population following the Spanish war increased, and in 1900 there was a severe epidemic.

*Stegomyia calopus* was established as the carrier of the fever early in 1901, and then antimosquito measures were immediately begun. Against adult mosquitoes no general measures were attempted, although screening and fumigation were carried out in quarters occupied by yellow-fever patients or that had been occupied by yellow-fever patients. It was found that the Stegomyia bred principally in the rain-water collections in the city itself. The city was divided into about 30 districts, and to each district an inspector and two laborers were assigned, each district containing about a thousand houses. An order was issued by the mayor of Havana requiring all collections of water to be so covered that mosquitoes could not have access, a fine being imposed in cases where the order was not obeyed. The health department covered the rain-water barrels of poor families at public expense. All cesspools were treated with petroleum. All receptacles containing fresh water which did not comply with the law were emptied and on the second offense destroyed. The result of this work thoroughly done was to wipe out yellow fever in Havana, and there has not been a certain endemic case since that time.

In what is termed the New Orleans epidemic of 1905 a striking illustration of the value of this recently acquired mosquito-transmission knowledge is seen. The presence of yellow fever in the city was first recognized about the 1st of July, but it was the 12th of August before the Public Health and Marine-Hospital Service was put in complete control of the situation. By that time the increase in new cases and deaths rendered it practically certain that the disease was as widespread as during the terrible epidemic of 1878. There had been up to that date 142 deaths from a total of 913 cases, as against 152 deaths from a total of 519 cases in 1878. The Public Health and Marine-Hospital Service, under Doctor White, took hold of the situation with energy, basing its measures almost entirely upon a warfare against *Stegomyia calopus*. The disease began almost immediately to abate, and the result at the close of the season indicated 460 deaths, as against 4,046 in 1878, a virtual saving of over 3,500 lives. The

following table of deaths from yellow fever in New Orleans from 1847 to 1905 points out most strikingly the value of this antimosquito work:

TABLE II.—*Comparative table of deaths from yellow fever in New Orleans during various years.*

| Month. | Year. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1847. | 1848. | 1853. | 1854. | 1855. | 1858. | 1867. | 1878. | 1905. |
| May | | | 2 | | | | | | |
| June | | 4 | 31 | 2 | 5 | 2 | 3 | | |
| July | 74 | 33 | 1,521 | 29 | 382 | 132 | 11 | 26 | 35 |
| August | 965 | 200 | 5,133 | 532 | 1,286 | 1,140 | 255 | 1,025 | 236 |
| September | 1,100 | 467 | 982 | 1,234 | 874 | 2,204 | 1,637 | 1,780 | 107 |
| October | 198 | 126 | 147 | 490 | 97 | 1,137 | 1,072 | 1,065 | 59 |
| November | 12 | 20 | 28 | 131 | 19 | 224 | 103 | 147 | 23 |
| December | 10 | | 4 | 7 | 7 | 15 | 26 | 3 | |
| Months unknown | 445 | 22 | | | | | | | |
| Total | 2,804 | 872 | 7,848 | 2,425 | 2,670 | 4,854 | 3,107 | 4,046 | 460 |

The epidemics of 1848, 1854, and 1855 are least comparable with that of 1905 because they immediately succeeded severe epidemics to which were due very many immunes.

The population of New Orleans by the United States Census was 130,565 in 1850; 168,675 in 1860; 191,418 in 1870; 216,090 in 1880, and 287,104 in 1900.

## WORK ON THE ISTHMUS OF PANAMA.

The United States Government has very properly used the services of Colonel Gorgas, who was in charge of the eminently successful work at Havana, by appointing him chief sanitary officer of the Canal Zone during the digging of the canal. In 1904 active work was begun, and Colonel Gorgas was fortunate in having the services of Mr. Le Prince, who had been chief of his mosquito brigades in Havana, and therefore was perfectly familiar with antimosquito methods. In Panama, as in Havana, the population had depended principally upon rain water for domestic purposes, so that every house had cisterns, water barrels, and such receptacles for catching and storing rain water. The city was divided up into small districts with an inspector in charge of each district. This inspector was required to cover his territory at least twice a week and to make a report upon each building with regard to its condition as to breeding places of mosquitoes. All the cisterns, water barrels, and other water receptacles in Panama were covered as in Havana, and in the water barrels spigots were inserted so that the covers would not have to be taken off. Upon first inspection, in March, 4,000 breeding places were reported. At the end of October less than 400 containing larvæ were recorded. This gives one a fair idea of the consequent rapid

decrease in the number of mosquitoes in the city. These operations were directed primarily against the yellow-fever mosquito, and incidentally against the other common species that inhabit rain-water barrels. Against the Anopheles in the suburbs the same kind of work was done as was done in Havana, with exceptionally good results.

The same operations were carried on in the villages between Panama and Colon. There are some twenty of these villages, running from 500 to 3,000 inhabitants each. Not a single instance of failure has occurred in the disinfection of these small towns, and the result of the whole work has been the apparent elimination of yellow fever and the very great reduction of malarial fever.

The remarkable character of these results can only be judged accurately by comparative methods. It is well known that during the French occupation there was an enormous mortality among the European employees, and this was a vital factor in the failure of the work. Exact losses can not be estimated, since the work was done under 17 different contractors. These contractors were charged $1 a day for every sick man to be taken care of in the hospital of the company. Therefore it often happened that when a man became sick his employer discharged him, so that he would not have to bear the expense of hospital charges. There was no police patrol of the territory and many of these men died along the line. Colonel Gorgas has stated that the English consul, who was at the Isthmus during the period of the French occupation, is inclined to think that more deaths of employees occurred out of the hospital than in it. A great many were found to have died along the roadside while endeavoring to find their way to the city of Panama. The old superintendent of the French hospital states that one day 3 of the medical staff died from yellow fever, and in the same month 9 of the medical staff. Thirty-six Roman Catholic sisters were brought over as nurses, and 24 died of yellow fever. On one vessel 18 young French engineers came over, and in a month after their arrival all but one died.

Now that the relation of the mosquito to yellow fever is well understood, it was found during the first two years under Doctor Gorgas that, although there were constantly one or more yellow-fever cases in the hospital, and although the nurses and physicians were all nonimmunes, not a single case of yellow fever was contracted in that way. The nurses never seemed to consider that they were running any risk in attending yellow fever cases night and day in screened wards, and the wives and families of officers connected with the hospital lived about the grounds, knowing that yellow fever was constantly being brought into the grounds and treated in near-by buildings. Americans, sick from any cause, had no fear when being treated in beds immediately adjoining those of yellow-fever patients. Colonel Gorgas and Doctor Carter lived in the old ward

used by the French for their officers, and Colonel Gorgas thinks it safe to say that more men had died from yellow fever in that building under the French régime than in any other building of the same capacity at present standing. He and Doctor Carter had their wives and children with them, which would formerly have been considered the height of recklessness, but they looked upon themselves, under the now recognized precautions, as being as safe, almost, as they would have been in Philadelphia or Boston.

No figures of the actual cost of the antimosquito work, either in Havana or in the Panama Canal Zone, are accessible to the writer, but it is safe to say that it was not exorbitant, and that it was not beyond the means of any well-to-do community in tropical regions.

## THE TYPHOID FLY, COMMONLY KNOWN AS THE HOUSE FLY.

The name "typhoid fly" is here proposed as a substitute for the name "house fly," now in general use. People have altogether too long considered the house fly as a harmless creature, or, at the most, simply a nuisance. While scientific researches have shown that it is a most dangerous creature from the standpoint of disease, and while popular opinion is rapidly being educated to the same point, the retention of the name house fly is considered inadvisable, as perpetuating in some degree the old ideas. Strictly speaking, the term "typhoid fly" is open to some objection, as conveying the erroneous idea that this fly is solely responsible for the spread of typhoid, but considering that the creature is dangerous from every point of view, and that it is an important element in the spread of typhoid, it seems advisable to give it a name which is almost wholly justified and which conveys in itself the idea of serious disease. Another repulsive name that might be given to it is "manure fly," but recent researches have shown that it is not confined to manure as a breeding place, although perhaps the great majority of these flies are born in horse manure. For the end in view, "typhoid fly" is considered the best name.

The true connection of the so-called house fly with typhoid fever and the true scientific evidence regarding its rôle as a carrier of that disease have only recently been worked out. Celli in 1888 fed flies with pure cultures of the typhoid bacillus, and examined their contents and dejections microscopically and culturally. Inoculations of animals were also made, proving that the bacilli which passed through flies were virulent. Dr. George M. Kober, familiar with Celli's researches, in his report on the prevalence of typhoid fever in the District of Columbia, published in 1895, called especial attention to the danger of the contamination of food supplies by

flies coming from the excreta of typhoid patients. The prevalence of typhoid fever in the concentration camps of the United States Army in the summer of 1898 brought about the appointment of an army typhoid commission consisting of Drs. Walter Reed, U. S. Army, Victor M. Vaughan, U. S. Volunteers, and E. O. Shakespeare, U. S. Volunteers. A paper read by Doctor Vaughan before the annual meeting of the American Medical Association at Atlantic City, N. J., June 6, 1900, contained the following conclusions with regard to flies:

"27. *Flies undoubtedly served as carriers of the infection.*

"My reasons for believing that flies were active in the dissemination of typhoid may be stated as follows:

"*a.* Flies swarmed over infected fecal matter in the pits and then visited and fed upon the food prepared for the soldiers at the mess tents. In some instances where lime had recently been sprinkled over the contents of the pits, flies with their feet whitened with lime were seen walking over the food.

"*b.* Officers whose mess tents were protected by means of screens suffered proportionately less from typhoid fever than did those whose tents were not so protected.

"*c.* Typhoid fever gradually disappeared in the fall of 1898, with the approach of cold weather, and the consequent disabling of the fly.

"It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, fecal matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that the typhoid bacillus may be carried in the digestive organs of the fly and may be deposited with its excrement."

There were also many important conclusions which bear upon the fly question. For example, it was shown that every regiment in the United States service in 1898 developed typhoid fever, nearly all of them within eight weeks after assembling in camps. It not only appeared in every regiment in the service, but it became epidemic both in small encampments of not more than one regiment and in the larger ones consisting of one or more corps. All encampments located in the Northern as well as in the Southern States exhibited typhoid in epidemic form. The miasmatic theory of the origin of typhoid fever and the pythogenic theory[a] were not supported by the investigations of the commission, but the doctrine of the specific

[a] This theory is founded upon the belief that the colon germ may undergo a ripening process by means of which its virulence is so increased and altered that it may be converted into the typhoid bacillus or at least may become the active agent in the causation of typhoid fever.

origin of the fever was confirmed. The conclusion was reached that the fever is disseminated by the transference of the excretions of an infected individual to the alimentary canals of others, and that a man infected with typhoid fever may scatter the infection in every latrine or regiment before the disease is recognized in himself, while germs may be found in the excrement for a long time after the apparently complete recovery of the patient. Infected water was not an important factor in the spread of typhoid in the national encampments of 1898, but about one-fifth of the soldiers in the national encampments in the United States during that summer developed this disease, while more than 80 per cent of the total deaths were caused by typhoid.

In 1899 the writer began the study of the typhoid or house fly under both country and city conditions. He made a rather thorough investigation of the insect fauna of human excrement, and made a further investigation of the species of insects that are attracted to food supplies in houses. In a paper entitled "A Contribution to the Study of the Insect Fauna of Human Excrement (with special reference to the spread of typhoid fever by flies)," published in the Proceedings of the Washington Academy of Sciences, Volume II, pages 541–604, December 28, 1900, he showed that 98.8 per cent of the whole number of insects captured in houses throughout the whole country under the conditions indicated above were *Musca domestica*, the typhoid or house fly. He showed further that this fly, while breeding most numerously in horse stables, is also attracted to human excrement and will breed in this substance. It was shown that in towns where the box privy was still in existence the house fly is attracted to the excrement, and, further, that it is so attracted in the filthy regions of a city where sanitary supervision is lax and where in low alleys and corners and in vacant lots excrement is deposited by dirty people. He stated that he had seen excrement which had been deposited overnight in an alleyway in South Washington swarming with flies under the bright sunlight of a June morning (temperature 92° F.), and that within 30 feet of these deposits were the open windows and doors of the kitchens of two houses kept by poor people, these two houses being only elements in a long row. The following paragraph is quoted from the paper just cited:

"Now, when we consider the prevalence of typhoid fever and that virulent typhoid bacilli may occur in the excrement of an individual for some time before the disease is recognized in him, and that the same virulent germs may be found in the excrement for a long time after the apparent recovery of a patient, the wonder is not that typhoid is so prevalent but that it does not prevail to a much greater

extent. Box privies should be abolished in every community. The depositing of excrement in the open within town or city limits should be considered a punishable misdemeanor in communities which have not already such regulations, and it should be enforced more rigorously in towns in which it is already a rule. Such offenses are generally committed after dark, and it is often difficult or even impossible to trace the offender; therefore, the regulation should be carried even further and require the first responsible person who notices the deposit to immediately inform the police, so that it may be removed or covered up. Dead animals are so reported; but human excrement is much more dangerous. Boards of health in all communities should look after the proper treatment or disposal of horse manure, primarily in order to reduce the number of house flies to a minimum, and all regulations regarding the disposal of garbage and foul matter should be made more stringent and should be more stringently enforced."

In the opening sentence of the paragraph just quoted attention was called to the activity of bacilli in excreta passed by individuals after apparent recovery from typhoid. Since the paper in question was published, more especial attention has been drawn by medical men to this point, and it has been shown that individuals who are chronic spreaders of the typhoid germs are much more abundant than was formerly supposed. Dr. George A. Soper recently discovered a striking case of this kind in the person of a cook employed successively by several families in the vicinity of New York City, with the result that several cases of typhoid occurred in each of these families. In a paper by Doctor Davids and Professor Walker, read before the Royal Sanitary Institute of London during the present season, the history was given of four personal carriers of typhoid who had communicated the disease to a number of people. These four carriers were detected in one city within a few months, and from this fact it can be argued with justice that such cases are comparatively numerous. This being true, the presence of unguarded miscellaneous human excreta deposited in city suburbs, in vacant lots, and in low alleyways intensifies to a very marked degree the danger that the food will become contaminated with typhoid bacilli by means of the typhoid or house fly. It is known, too, that the urine of persons who have suffered from typhoid fever often contains active typhoid bacilli for several weeks after the patients have recovered: consequently this also is a source of danger.

The importance of the typhoid fly as a carrier of the disease in army camps, as shown in the Spanish war and in the Boer war and in the camps of great armies of laborers engaged in gigantic enterprises like the digging of the Panama canal, is obvious, but what

has just been stated indicates that even under city conditions the influence of this fly in the spread of this disease has been greatly underestimated. It is not claimed that under city conditions the house fly becomes by this argument a prime factor in the transfer of the disease, but it must obviously take a much higher relative rank among typhoid conveyers than it has hitherto assumed. Perhaps even under city conditions it must assume third rank—next to water and milk.

It is not alone as a carrier of typhoid that this fly is to be feared. In the same way it may carry nearly all the intestinal diseases. It is a prime agent in the spreading of summer dysentery, and in this way is unquestionably responsible for the death of many children in summer. One of the earliest accurate scientific studies of the agency of insects in the transfer of human disease was in regard to flies as spreaders of cholera. The belief in this agency long preceded its actual proof. Dr. G. E. Nicholas, in the London Lancet, Volume II, 1873, page 724, is quoted by Nuttall as writing as follows regarding the cholera prevailing at Malta in 1849: "My first impression of the possibility of the transfer of the disease by flies was derived from the observation of the manner in which these voracious creatures, present in great numbers, and having equal access to the dejections and food of patients, gorged themselves indiscriminately and then disgorged themselves on the food and drinking utensils. In 1850 the *Superb*, in common with the rest of the Mediterranean squadron, was at sea for nearly six months; during the greater part of the time she had cholera on board. On putting to sea, the flies were in great force; but after a time the flies gradually disappeared, and the epidemic slowly subsided. On going into Malta Harbor, but without communicating with the shore, the flies returned in greater force, and the cholera also with increased violence. After more cruising at sea, the flies disappeared gradually with the subsidence of the disease."

Accurate scientific bacteriological observations by Tizzoni and Cattani in 1886 showed definitely active cholera organisms in the dejecta of flies caught in the cholera wards in Bologna, Italy. These observations were subsequently verified and extended by Simonds, Offelmann, Macrae, and others.

With tropical dysentery and other enteric diseases practically the same conditions exist. In a report by Daniel D. Jackson to the committee on pollution, of the Merchants' Association in New York, published in December, 1907, the results of numerous observations upon the relation of flies to intestinal diseases are published, and the relation of deaths from intestinal diseases in New York City to the

activity and prevalence of the common house fly is shown not only by repeated observations but also by an interesting plotting of the curve of abundance of flies in comparison with the plotted curve of abundance of deaths from intestinal diseases, indicating that the greatest number of flies occurred in the weeks ending July 27 and August 3; also, that the deaths from intestinal diseases rose above the normal at the same time at which flies became prevalent, culminated at the same high point, and fell off with slight lag at the time of the gradual falling off of the prevalence of the insects.

Similar studies have been carried on during the summer of 1908 in the city of Washington, and the curve of typhoid-fly abundance for the whole city, as well as that for a district comprising eight city squares in which intensive studies have been made both of flies and of disease, will be plotted at the close of the season. At the time of present writing this work has not been completed.

The typhoid fly also possesses importance as a disseminator of the bacilli of tuberculosis. In a paper by Dr. Frederick T. Lord, of Boston, reprinted from the Boston Medical and Surgical Journal for December 15, 1904, pages 651-654, the following conclusions are reached:

"1. Flies may ingest tubercular sputum and excrete tubercle bacilli, the virulence of which may last for at least fifteen days.

"2. The danger of human infection from tubercular flyspecks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from flyspecks is unlikely. If mechanically disturbed, infection of the surrounding air may occur.

"As a corollary to these conclusions, it is suggested that—

"3. Tubercular material (sputum, pus from discharging sinuses, fecal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies, lest they act as disseminators of the tubercle bacilli.

"4. During the fly season greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis and laboratories where tubercular material is examined.

"5. As these precautions would not eliminate fly infection by patients at large, foodstuffs should be protected from flies which may already have ingested tubercular material."

From all these facts it appears that the most important part played by the typhoid fly or house fly in the human economy is to carry bacteria from one place to another. The following table and comments are taken from Bulletin No. 51 (April, 1908), of the Storrs Agricultural Experiment Station, Storrs, Conn., entitled "Sources of Bacteria in Milk," by W. M. Esten and C. J. Mason:

TABLE III.—*Sources of bacteria from flies.*

| Date. | Source. | Total number. | Total lactic bacteria. | Rapid liquefying bacteria. | Slow liquefying bacteria. | *Bacterium lactis acidi.* Group A. Class 1. | *Coli aero genes* Group A. Class 2. |
|---|---|---|---|---|---|---|---|
| 1907. | | | | | | | |
| July 27 | (*a*) 1 fly, bacteriological laboratory | 3,150 | 250 | 600 | 100 | ..... | ..... |
| July 27 | (*b*) 1 fly, bacteriological laboratory | 550 | 100 | 0 | 0 | ..... | ..... |
| Aug. 6 | (*c*) 19 cow-stable flies | 7,980,000 | 220,000 | 0 | 20,000 | ..... | ..... |
| | Average per fly | 420,000 | 11,600 | 0 | 1,000 | ..... | ..... |
| Aug. 14 | (*d*) 94 swill-barrel flies | 155,000,000 | 8,950,000 | 0 | 0 | 4,320,000 | 4,630,000 |
| | Average per fly | 1,660,000 | 95,300 | 0 | 0 | 46,000 | 49,300 |
| Aug. 14 | (*e*) 141 pigpen flies | 133,000,000 | 2,110,000 | 100,000 | 266,000 | 933,000 | 1,176,000 |
| | Average per fly | 923,000 | 18,700 | 700 | 1,150 | 6,500 | 12,200 |
| Sept. 4 | (*f*) 18 swill-barrel flies | 118,800,000 | 10,480,000 | 0 | 14,500,000 | 10,480,000 | 30,000,000 |
| | Average per fly | 6,600,000 | 2,182,000 | 0 | 804,000 | 582,000 | 1,600,000 |
| Sept. 21 | (*g*) 30 dwelling-house flies | 1,425,000 | 125,000 | 0 | 12,500 | ..... | ..... |
| | Average per fly | 47,580 | 4,167 | 0 | 417 | ..... | ..... |
| Sept. 21 | (*h*) 26 dwelling-house flies | 22,880,000 | 22,596,000 | 120,000 | 34,000 | ..... | ..... |
| | Average per fly | 880,000 | 869,000 | 4,600 | 1,300 | ..... | ..... |
| Sept. 27 | (*i*) 110 dwelling-house flies | 35,500,000 | 13,670,000 | 8,840,000 | 125,000 | ..... | ..... |
| | Average per fly | 322,700 | 124,200 | 80,300 | 1,100 | ..... | ..... |
| Aug. 20 | (*j*) 1 large bluebottle blowfly | 308,700 | (*a*) | ..... | ..... | ..... | ..... |
| | Total average of 414 flies | 1,222,570 | 367,300 | 7,830 | 73,500 | ..... | ..... |
| | Average per cent of 414 flies | ..... | 30 | 6 | 6 | ..... | ..... |
| | Average per fly of 256 flies, experiments (*d*), (*e*), and (*f*) | 3,061,000 | 765,000 | 230 | 268,700 | 211,500 | 753,800 |
| | Average per cent of 256 flies, experiments (*d*), (*e*), and (*f*) | ..... | 25 | ..... | 8 | 7 | 18 |

[a] 2,200 mold spores.

"From the above table the bacterial population of 414 flies is pretty well represented. The domestic fly is passing from a disgusting nuisance and troublesome pest to a reputation of being a dangerous enemy to human health. A species of mosquito has been demonstrated to be the cause of the spread of malaria. Another kind of mosquito is the cause of yellow fever, and now the house fly is considered an agency in the distribution of typhoid fever, summer complaint, cholera infantum, etc.

"The numbers of bacteria on a single fly may range all the way from 550 to 6,600,000. Early in the fly season the numbers of bacteria on flies are comparatively small, while later the numbers are comparatively very large. The place where flies live also determines largely the numbers that they carry. The average for the 414 flies was about one and one-fourth million bacteria on each. It hardly seems possible for so small a bit of life to carry so large a number of organisms. The method of the experiment was to catch the flies from the several sources by means of a sterile fly net, introduce them into a sterile bottle, and pour into the bottle a known quantity of sterilized water, then shake the bottle to wash the bacteria from their bodies, to simulate the number of organisms that would come from a fly in falling into a lot of milk. In experiments '*d*,' '*e*,' and '*f*'

the bacteria were analyzed into four groups. The objectionable class, *coli-aerogenes* type, was two and one-half times as abundant as the favorable acid type. If these flies stayed in the pigpen vicinity there would be less objection to the flies and the kinds of organisms they carry, but the fly is a migratory insect and it visits everything 'under the sun.' It is almost impossible to keep it out of our kitchens, dining rooms, cow stables, and milk rooms. The only remedy for this rather serious condition of things is, remove the pigpen as far as possible from the dairy and dwelling house. Extreme care should be taken in keeping flies out of the cow stable, milk rooms, and dwellings. Flies walking over our food are the cause of one of the worst contaminations that could occur from the standpoint of cleanliness and the danger of distributing disease germs."

The danger of the typhoid or house fly in the carriage of disease has thus been abundantly demonstrated. Further than this, it is an intolerable nuisance. With mosquitoes it necessitates an annual outlay for window and door screens in the United States of not less than ten millions of dollars. As a carrier of disease it causes a loss of many millions of dollars annually. Dr. G. N. Kober, in a paper prepared for the Governors' Conference on the Conservation of Natural Resources, held at the White House in May, 1908, entitled "The Conservation of Life and Health by Improved Water Supply," presented figures showing that the decrease in the vital assets of the country through typhoid fever in a single year is more than $350,000,000. The house fly, as an important agent in the spread of this disease, is responsible for a very considerable portion of this decrease in vital assets. As an agency in the spread of other intestinal diseases, this sum must be greatly increased, and yet it is allowed to breed unrestricted all over the United States; it is allowed to enter freely the houses of the great majority of our people; it is allowed to spread bacteria freely over our food supplies in the markets and in the kitchens and dining rooms of private houses, and, to use the happy phraseology of Dr. Theobald Smith, "when we go into public restaurants in midsummer we are compelled to fight for our food with the myriads of house flies which we find there alert, persistent, and invincible."

Even if the typhoid or house fly were a creature difficult to destroy, the general failure on the part of communities to make any efforts whatever to reduce its numbers could properly be termed criminal neglect; but since, as will be shown, it is comparatively an easy matter to do away with the plague of flies, this neglect becomes an evidence of ignorance or of a carelessness in regard to disease-producing filth which to the informed mind constitutes a serious blot on civilized methods of life.

Strange as it may seem, an exhaustive study of the conditions which produce house flies in numbers has never been made. The life history of the insect in general was, down to 1873, mentioned in only three European works and few exact facts were given. In 1873 Dr. A. S. Packard, then of Salem, Mass., studied the transformations of the insect and gave descriptions of all stages, showing that the growth of a generation from the egg state to the adult occupies from 10 to 14 days.

In 1895 the writer traced the life history in question, indicating that 120 eggs are laid by a single female, and that in Washington, in midsummer, a generation is produced every 10 days. Although numerous substances were experimented with, he was able to breed the fly only in horse manure. Later investigations indicated that the fly will breed in human excrement and in other fermenting vegetable and animal material, but that the vast majority of the flies that infest dwelling houses, both in cities and on farms, come from horse manure.

In 1907 careful investigations carried on in the city of Liverpool by Robert Newstead, lecturer in economic entomology and parasitology in the School of Tropical Medicine of the University of Liverpool, indicated that the chief breeding places of the house fly in that city should be classified under the following heads:

(1) Middensteads (places where dung is stored) containing horse manure only.

(2) Middensteads containing spent hops.

(3) Ash pits containing fermenting materials.

He found that the dung heaps of stables containing horse manure only were the chief breeding places. Where horse and cow manures were mixed the flies bred less numerously, and in barnyards where fowls were kept and allowed freedom relatively few of the house flies were found. Only one midden containing warm spent hops was inspected, and this was found to be as badly infested as any of the stable middens. A great deal of time was given to the inspection of ash pits, and it was found that wherever fermentation had taken place and artificial heat had been thus produced, such places were infested with house-fly larvæ and pupæ, often to the same alarming extent as in stable manure. Such ash pits as these almost invariably contained large quantities of old bedding or straw and paper, paper mixed with human excreta, or old rags, manure from rabbit hutches, etc., or a mixture of all these. About 25 per cent of the ash pits examined were thus infested, and house flies were found breeding in smaller numbers in ash pits in which no heat had been engendered by fermentation. The house fly was also found breeding by Mr. Newstead in certain temporary breeding places, such as collections

of fermenting vegetable refuse, accumulations of manure at the wharves, and in bedding in poultry pens.

Still more recent investigations were carried on during 1908 by Prof. S. A. Forbes, State entomologist of Illinois, who has reared it in large numbers from the contents of paunches of slaughtered cattle, from refuse hog hairs, from tallow vats, from carcasses of various animals, miscellaneous garbage, and so on.

All this means that if we allow the accumulation of filth we will have house flies, and if we do not allow it to accumulate we will have no house flies. With the careful collection of garbage in cans and the removal of the contents at more frequent intervals than 10 days, and with the proper regulation of abattoirs, and more particularly with the proper regulation of stables in which horses are kept, the typhoid fly will become a rare species. It will not be necessary to treat horse manure with chlorid of lime or with kerosene or with a solution of Paris green or arsenate of lead, if stable men are required to place the manure daily in a properly covered receptacle and if it is carried away once a week.

The orders of the health department of the District of Columbia, published May 3, 1906, if carried out will be very effective. These orders may be briefly condensed as follows:

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain, in connection therewith, a bin or pit for the reception of manure, and pending the removal from the premises of the manure from the animal or animals shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water, and shall in all other respects be water-tight, except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in any of the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle, which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the

bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of these provisions shall, upon conviction thereof, be punished by a fine of not more than $40 for each offense.

In addition to this excellent ordinance, others have been issued from the health department of the District of Columbia which provide against the contamination of exposed food by flies and by dust. The ordinances are excellently worded so as to cover all possible cases. They provide for the registration of all stores, markets, cafés, lunch rooms, or of any other place where food or beverage is manufactured or prepared for sale, stored for sale, offered for sale, or sold, in order to facilitate inspection, and still more recent ordinances provide for the registration of stables. An excellent campaign was begun during the summer of 1908 against insanitary lunch rooms and restaurants. A number of cases were prosecuted, but conviction was found to be difficult.

For one reason or another, the chief reason being the lack of a sufficient force of inspectors under the control of the health officers, the ordinance in regard to stables has not been carried out with that perfection which the situation demands. In the summer of 1896, the health officer of the District, Dr. W. C. Woodward, designated a region in Washington bounded by Pennsylvania avenue, Sixth street, Fifteenth street, and the Potomac River, which was to be watched by assistants of the writer. Twenty-four stables were located in this region and were visited weekly by two assistants chosen for the purpose. The result was that on the whole the manure was well looked after and the number of flies in the region in question was very considerably reduced during the time of inspection.

Were simple inspection of stables all that is needed, a force of four inspectors, specially detailed for this work, could cover the District of Columbia, examining every stable, after they were once located and mapped, once a week. The average salary of an inspector is $1,147, so that the total expense for the first year would be something like $4,500. But the inspectors' service is complicated by the matter of prosecution. Much of the time of inspectors would be taken in the prosecution of the owners of neglected premises. Moreover, the health officer has found during the summer of 1908, in his prosecution of the owners or managers of insanitary restaurants, that his inspectors were practically sworn out of court by the multiplicity of opposing evidence. This means that it will be necessary in such cases to send two inspectors together in all cases, so that the testimony of one may be supported by the testimony of the other. This, perhaps, would double the number of necessary inspectors, making the expense of the service something over $9,000. It is reasonably safe to state, however, that

with such an expense for competent service, or perhaps with a slightly added expense, the typhoid fly could be largely eliminated as an element in the transfer of disease in the District of Columbia, and the difficulty which the authorities have had in locating the cause of a very considerable proportion of the cases of typhoid in the District for the past two or three years indicates plainly to the mind of the writer that the typhoid fly is a much more important element than has been supposed. It is a comforting although comparatively insignificant fact and a matter of common observation that in certain sections of the city the typhoid fly has been much less numerous during the past summer than in previous years. The writer is inclined to attribute this to the gradual disappearance of horse stables in such sections, brought about by the rapidly increasing use of motor vehicles.

A significant paragraph in Mr. Newstead's Liverpool report, referred to above, contains the following words: "The most strenuous efforts should be made to prevent children defecating in the courts and passages; or that the parents should be compelled to remove such matter immediately; and that defecation in stable middens should be strictly forbidden. The danger lies in the overwhelming attraction which such fecal matter has for house flies, which later may come into direct contact with man or his foodstuffs. They may, as Veeder puts it, 'In a very few minutes * * * load themselves with dejections from a typhoid or dysenteric patient, not as yet sick enough to be in hospital or under observation, and carry the poison so taken up into the very midst of the food and water ready for use at the next meal. There is no long, roundabout process involved.'"

The writer has already referred to this general subject in his remarks on the depositing of excrement in the open within town or city limits, but Newstead's specific reference to children reminds one that in the tenement districts of the older great cities of England and other parts of Europe there occur opportunities for transfer of disease which, while probably less numerous in the newer cities of the United States, nevertheless must still exist and be a constant danger.

We have thus shown that the typhoid or house fly is a general and common carrier of pathogenic bacteria. It may carry typhoid fever, Asiatic cholera, dysentery, cholera morbus, and other intestinal diseases; it may carry the bacilli of tuberculosis and certain eye diseases; it is everywhere present, and it is disposed of with comparative ease. It is the duty of every individual to guard so far as possible against the occurrence of flies upon his premises. It is the duty of every community, through its board of health, to spend money in the warfare against this enemy of mankind. This duty is as pronounced as though the community were attacked by bands of ravenous wolves.

As a matter of fact, large sums of money are spent annually in the protection of property in the United States. Large sums of money are spent also in health matters; but the expenditure for protection from flies is very small and is misdirected. There is much justification for the following criticism published editorially in the Journal of the American Medical Association for August 22, 1908, under the caption, "National Farm Commission and Rural Sanitation:"

"The President calls attention to the fact that all efforts to aid the farmers have hitherto been directed to improving their material welfare, while the man himself and his family have been neglected. Nowhere is this more marked than in the attitude of the General Government in matters relating to sanitation. It is a trite saying that whereas the Government, through the Department of Agriculture, aids the farmer generously in caring for the health of his hogs, sheep, etc., it does nothing for his own health. The Government issues notices to the farmer of the injury done to his crops by the cotton-boll weevil and the potato bugs and how to combat them, but the injury the mosquito does in spreading malaria to the people who pick the cotton and hoe the potatoes is not impressed on him. The fact that horseflies may carry anthrax to his cattle is dealt with at considerable length, but the diseases which the house fly spreads to the milk and to the farmer's family attract practically no attention. How to build a hogpen or a sanitary barn is the subject of a number of government publications, but how to build a sanitary privy which will prevent the spread of typhoid, hook worm, and many other diseases is regarded as of strictly local interest."

But this criticism is not entirely justified, since there was published by the Bureau of Entomology of the United States Department of Agriculture, in 1900, a Farmers' Bulletin, entitled "How Insects Affect Health in Rural Districts,"[a] in which all of these points mentioned by the editor of the Journal of the American Medical Association have been touched upon, and at the date of present writing 192,000 copies of this bulletin have been distributed among the people. Moreover, a number of years ago a circular[b] was published on the subject of the house fly, calling attention to its dangers and giving instructions such as are covered in a general way in this article, and some 18,000 copies of this circular have also been distributed. This is an indication that the General Government is by no means blind to the people's needs in such matters as we have under consideration, but further work should be done. That the English Government is awaking to the same need is shown by the fact that, in the parliamentary vote of the present year in aid of

[a] Farmers' Bulletin No. 155.

[b] Circular No. 35, Bureau of Entomology, 1891, afterwards reissued in revised form as Circular No. 71.

scientific investigations concerning disease, one of the projects supported by the General Government was the investigation of Doctors Copeman and Nuttall on flies as carriers of disease.

A leading editorial in an afternoon paper of the city of Washington, of October 20, 1908, bears the heading, "Typhoid a National Scourge," arguing that it is to-day as great a scourge as tuberculosis. The editorial writer might equally well have used the heading "Typhoid a National Reproach," or perhaps even "Typhoid a National Crime," since it is an absolutely preventable disease. And as for the typhoid fly, that a creature born in indescribable filth and absolutely swarming with disease germs should practically be invited to multiply unchecked, even in great centers of population, is surely nothing less than criminal.

## ENDEMIC DISEASE AS AFFECTING THE PROGRESS OF NATIONS.

In referring to the spread of malaria in Greece, the relation of this disease to the rise and fall of national power has been touched upon in an earlier paragraph of this bulletin (p. 9). The subject is one of the widest importance and deserves a more extended consideration.

The following paragraphs are quoted from Ronald Ross's address on Malaria in Greece, delivered before the Oxford Medical Society, November 29, 1906:

"Now, what must be the effect of this ubiquitous and everlasting incubus of disease on the people of modern Greece? Remember that the malady is essentially one of infancy among the native population. Infecting the child one or two years after birth, it persecutes him until puberty with a long succession of febrile attacks, accompanied by much splenomegaly and anæmia. Imagine the effect it would produce upon our own children here in Britain. It is true that our children suffer from many complaints—scarlatina, measles, whooping cough—but these are of brief duration and transient. But now add to these, in imagination, a malady which lasts for years, and may sometimes attack every child in a village. What would be the effect upon our population—especially our rural population—upon their numbers and upon the health and vigour of the survivors? It must be enormous in Greece. People often seem to think that such a plague strengthens a race by killing off the weaker individuals: but this view rests upon the unproven assumption that it is really the weaker children which can not survive. On the contrary, experience seems to show that it is the stronger blood which suffers most—the fair, northern blood which nature attempts constantly to pour into the southern lands. If this be true, the effect of malaria will be constantly to resist the invigorating influx which nature has provided: and there are many facts in the history of India, Italy, and Africa which could be brought forward in support of this hypothesis.

"We now come face to face with that profoundly interesting subject, the political, economical, and historical significance of this great disease. We know that malaria must have existed in Greece ever since the time of Hippocrates, about 400 B. C. What effect has it had on the life of the country? In prehistoric times Greece was certainly peopled by successive waves of Aryan invaders from the north—probably a fair-haired people—who made it what it became, who conquered Persia and Egypt, and who created the sciences, arts, and philosophies which we are only developing further to-day. That race reached its climax of development at the time of Pericles. Those great and beautiful valleys were thickly peopled by a civilization which in some ways has not been excelled. Everywhere there were cities, temples, oracles, arts, philosophies, and a population vigorous and well trained in arms. Lake Kopais, now almost deserted, was surrounded by towns whose massive works remain to this day. Suddenly, however, a blight fell over all. Was it due to internecine conflict or to foreign conquest? Scarcely; for history shows that war burns and ravages, but does not annihilate. Thebes was thrice destroyed, but thrice rebuilt. Or was it due to some cause, entering furtively and gradually sapping away the energies of the race by attacking the rural population, by slaying the new-born infant, by seizing the rising generation, and especially by killing out the fair-haired descendant of the original settlers, leaving behind chiefly the more immunised and darker children of their captives, won by the sword from Asia and Africa? * * *

"I can not imagine Lake Kopais, in its present highly malarious condition, to have been thickly peopled by a vigorous race; nor, on looking at those wonderful figured tombstones at Athens, can I imagine that the healthy and powerful people represented upon them could have ever passed through the anæmic and splenomegalous infancy (to coin a word) caused by widespread malaria. Well, I venture only to suggest the hypothesis, and must leave it to scholars for confirmation or rejection. Of one thing I am confident, that causes such as malaria, dysentery, and intestinal entozoa must have modified history to a much greater extent than we conceive. Our historians and economists do not seem even to have considered the matter. It is true that they speak of epidemic diseases, but the endemic diseases are really those of the greatest importance. * * *

"The whole life of Greece must suffer from this weight, which crushes its rural energies. Where the children suffer so much, how can the country create that fresh blood which keeps a nation young? But for a hamlet here and there, those famous valleys are deserted. I saw from a spur of Helikon the sun setting upon Parnassus, Apollo sinking, as he was wont to do, towards his own fane at Delphi, and pouring a flood of light over the great Kopaik Plain. But it seemed

that he was the only inhabitant of it. There was nothing there. 'Who,' said a rich Greek to me, 'would think of going to live in such a place as that?' I doubt much whether it is the Turk who has done all this. I think it is very largely the malaria."

In considering carefully this suggestive argument of Major Ross does it not appear to indicate the tremendous influence that the prevalence of endemic disease must exert upon the progress of modern nations, and does it not bring the thought that those nations that are most advanced in sanitary science and preventive medicine will, other things being equal, assume the lead in the world's work? Who can estimate the influence of the sanitary laws of the Hebrew scriptures upon the extraordinary persistence of that race through centuries of European oppression—centuries full of plague years and of terrible mortality from preventable disease? And what more striking example can be advanced of the effect of an enlightened and scientifically careful attention to the most recent advances of preventive medicine upon the progress of nations than the mortality statistics of the Japanese armies in the recent Russo-Japanese war as compared with the corresponding statistics for the British army during the Boer war immediately preceding, or for the American Army during the Spanish war at a somewhat earlier date?

The consideration of these elements of national progress has been neglected by historians, but they are nevertheless of deep-reaching importance and must attract immediate attention in this age of advanced civilization. The world has entered the historical age when national greatness and national decay will be based on physical rather than moral conditions, and it is vitally incumbent upon nations to use every possible effort and every possible means to check physical deterioration.

# INDEX.


Page.

Abattoirs, regulations to avoid house flies 32
Anopheles mosquitoes (*see also* Mosquitoes, malaria).
disseminators of malaria 7
suppression in Panama 22
Ash pits containing fermenting material, breeding places of house fly 31
*Bacillus icteroides*, not proven to be causative germ of yellow fever 19
Bacteria from flies, census 29–30
in milk, sources 28–30
Bedbug, a carrier of disease 7
Bedding, old, in ash pits, breeding place of house fly 31
Bubonic plague, conveyance by fleas 7
Cafés, regulation to avoid house flies 33
Carcasses of animals, breeding places of house fly 32
Cholera, Asiatic, carriage by house fly 7, 27, 34
infantum, carriage by house fly 29
morbus, carriage by house fly 34
*Culex fasciatus*=*Stegomyia calopus* 19
Deaths from malaria in United States 9–10
typhoid fever in concentration camps, U. S. Army 24–25
yellow fever in United States 18, 31
Disease, endemic, as affecting progress of nations 36–38
Diseases, intestinal, dissemination by house fly 7
Dysentery, summer, carriage by house fly 27, 34
tropical, carriage by house fly 27, 34
Endemic disease as affecting progress of nations 36–38
Excrement, human, breeding place of house fly 31
Eye diseases, carriage by house fly 34
Fermenting animal and vegetable material, breeding places of house fly 31–32
Filariasis, transmission by a mosquito 7
Fleas, conveyors of bubonic plague 7
Flies, biting, carriers of sleeping sickness 7
Fly, house, breeding places 31–32
disseminator of cholera, Asiatic 7, 27, 34
infantum 29
morbus 34
dysentery, summer 27, 34
tropical 27
eye diseases 34
intestinal diseases 7, 27–28
purulent ophthalmia 7
typhoid fever 7
tuberculosis 7, 28, 34
legislation 32–36
life history 31
relation to typhoid fever 23–27
suppression feasible and all-important 30
manure, name for house fly 23
typhoid, name for house fly 23
Garbage, breeding place of house fly 32
collection to avoid house flies 32
Hippelates flies, carriers of pink eye 7
Hog hairs, refuse, breeding place of house fly 32
Hops, spent, breeding place of house fly 31
Insects affecting health, publications by Bureau of Entomology 35
Lunch rooms, regulation, to avoid house flies 33
Malaria, deaths in United States 9–10
dissemination by mosquitoes 7, 8–17
eradication at Ismailia, Suez Canal 16–17
in Greece 36–38

Page.
Malaria, in Italy, loss therefrom 11–12
Mauritius 11
Reunion 11
United States, history 9
loss in United States 9–14
Italy 11–12
mosquitoes. (*See* Anopheles mosquitoes and Mosquito, malaria.)
prevention 14–17
relation to agriculture and other industries of the South 13–14
suppression in Havana 17
Panama 21–23
Selangor, Federated Malay States 15–16
Manure, disposal, to avoid house flies 32–33
horse, breeding place of house fly 31
rabbit, in ash pits, breeding place of house fly 31
Markets, regulation, to avoid house flies 33
Milk, sources of bacteria therein 28–30
Mosquito, disseminator of filariasis 7
malaria 7
yellow fever 7
malaria (*see also* Anopheles mosquitoes).
suppression measures 15–17
yellow fever, suppression measures 19–23
Mosquitoes, losses in general which they occasion 8
through malaria which they occasion 8–17
yellow fever which they occasion 17–21
suppression in Panama 21–23
Nations, endemic disease as affecting progress 36–38
Ophthalmia, purulent, carriage by house fly 7
Paper, old, breeding place of house fly 31
Pink eye, carriage by Hippelates flies 7
Plague, bubonic. (*See* Bubonic plague.)
Poultry-house bedding, breeding place of house fly 32
Progress of nations as affected by endemic disease 36–38
Rags, old, in ash pits, breeding place of house fly 31
Restaurants, regulation, to avoid house flies 33
Sanitation, rural, necessity for government support 35
Slaughtered cattle paunches, breeding places of house fly 32
Sleeping sickness, carriage by biting flies 7
"Spotted fever," carriage by tick 7
Stable inspection against house flies, probable cost 33–34
Stables, regulation, to avoid house flies 32–33
*Stegomyia calopus* (*see also* Mosquito, yellow fever).
disseminator of yellow fever 7, 19, 20
Stores, regulation, to avoid house flies 33
Straw, old, in ash pits, breeding place of house fly 31
Tallow vats, breeding places of house fly 32
Tick, carrier of "spotted fever" 7
Tuberculosis, dissemination by house fly 7, 28, 34
Typhoid fever, a "National Reproach" 36
dissemination by house fly 7, 23–27, 34
in concentration camps, U. S. Army 24–25
loss in United States 30
Vegetable refuse, fermenting, breeding place of house fly 32
Yellow fever, cause, history of investigation 19
deaths in New Orleans 21
United States 18
dissemination by mosquito 7
history in America 17–18
loss in United States 18
mosquito. (*See* Mosquito, yellow fever.)
suppression in Havana and New Orleans 19–21
Panama 21–23

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